VOLUME 81 PAPER No. 760

PROCEEDINGS

AMERICAN SOCIETY OF CIVIL ENGINEERS

JULY, 1955

AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852

DISCUSSION OF PROCEEDINGS PAPERS

259, 611, 612

WATERWAYS DIVISION

Headquarters of the Society
33 W. 39th St.
New York 18, N. Y.

PRICE $0.50 PER COPY

Current discussion of papers sponsored by the Waterways Division is presented as follows:

This paper was published at 1745 S. State Street, Ann Arbor, Mich., by the American Society of Civil Engineers. Editorial and General Offices are at 33 West Thirty-ninth Street, New York 18, N.Y.

Discussion of
"GRAPHIC DESIGN OF ALLUVIAL CHANNELS"

by Ning Chien
(Proc. Paper 611)

E. W. LANE,[1] M. ASCE.—The writer believes that the development of improved methods for solving sediment problems will be along the line of learning to handle the flow and deposit of sediment quantitatively, just as we now handle the flow and storage of water. Of course, the methods for handling sediment are much more difficult to devise than those for water, but rapid progress is being made, and reasonably satisfactory quantitative solutions of many problems can be expected in the not far distant future. Dr. Chien's paper is a valuable forward step in the advance along these lines. The Author's examples show the way many problems can be solved by the application of the laws of sediment transport.

Although, as is true of practically all sediment problems, in the present state of the science very exact answers are not now available, Dr. Chien's results are likely to be the best it is now possible to obtain and probably better than is possible to obtain by any method.

In this paper, and also in his paper, A Concept of Lacey's Regime Theory,[2] Dr. Chien discusses the problem of determining channel width but does not give any method for selecting the width as he concludes that it is not important. The writer does not share this view, but believes that for artificial channels it is possible to compute the best channel width. For natural streams it seems possible to list the most important factors which influence this width.

For an artificial channel in earth to be stable, it must be free from scour and deposit. To be free from scour the shear at all points of the bed and banks must be less than the value which will cause scour. To prevent deposit the shear and resulting turbulence at all points must be high enough to prevent the deposition of sediment or, in other words, shear on the bed and banks must be of such magnitude and distribution that all of the sediment entering the channel will be transported through it. The shape of the cross-section and the longitudinal slope of the canal must be such that both of these requirements are met. Meeting these conditions will fix the width of the channel. A method for designing channels which will satisfy these requirements has been developed by the U. S. Bureau of Reclamation. The report on this method[3] discusses only in general terms the design of channels carrying heavy sediment loads and does not give methods of computing the sediment load which would be carried under given conditions but gives some details of methods of designing channels which will not scour the banks. Dr. Chien's diagrams appear to be a valuable aid in determining the conditions necessary to transport the sediment load required to prevent deposition.

1. Hydr. Engr., Fort Collins, Colo.
2. ASCE Proceedings Separate No. 620, February, 1955.
3. Progress Report on Studies on the Design of Stable Channels by the Bureau of Reclamation by E. W. Lane. ASCE Proceedings Separate No. 280.

The factors which influence natural stream width are numerous. If such a stream is in equilibrium they are substantially constant, even though the stream channel may shift in places so that it occupies an entirely new position. This frequently happens in meandering channels such as that of the Lower Mississippi River. In this case the width of the channel is the result of a balance between the conditions which tend to widen the channel by cutting away the banks and those which tend to resist widening or tend to narrow it by building up the banks on the side of the stream opposite to the places where bank scour is occurring. To keep the width the same, the building up of the banks must go on at the same rate as the bank cutting and the channel width of a stable stream is that width, which under the existing conditions, will produce this balance. The conditions which tend toward a high rate of bank cutting are: (1) high discharge, great discharge variability, steep slopes, large depths and great curvature of alignment; (2) low resistance to widening due to non-cohesive and small grain size materials and little vegetal growth. The principal conditions tending to resist widening are the resistivity of the bank material to scour, and are the opposite of those listed under (2) above as producing low resistance to widening. The principal factors tending to rapid building up of the banks are high concentration and settling rate of the transported material and the tendency of this sediment to form cohesive material, also, channel alignment which produces small shear and turbulence at certain places that are favorable to the deposit of the transported material. There is considerable interdependence of the factors mentioned, and some are undoubtedly less important than others. The more accuracy required in determining the width, the larger the number of factors which must be considered. Some of the factors are difficult to express in quantitative terms. Under these conditions a formula for determining width of a natural stream with a satisfactory degree of accuracy will be very difficult to obtain, but a listing of the variables involved may help in reaching a solution. Since no good method for obtaining material stream width is available, even somewhat unsatisfactory methods may be very useful. The development of another method is worthy of effort even if the new method is not completely satisfactory.

The writer wishes to acknowledge the assistance of Dr. M. L. Albertson in preparing this discussion.

Discussion of
"RIVER SURVEYS IN UNMAPPED TERRITORY"

by Gerard H. Matthes

T. H. F. NEVINS.[1]—All engineers who have experience of works in recently developed countries will appreciate the author's profound knowledge of the practical difficulties to be overcome. Not the least of these is language, even when one speaks the local tongue. In collecting data from the river-side population one must guard against misinterpretation and frame one's questions in accordance with the local mode of living. The writer, speaking the vernacular, once asked a village headman in Bengal if Ganges flood waters rose to where they were standing. The headman thought this an absurdity for the river was two miles away. By asking how high the women tucked up their skirts when planting rice, however, it was deduced that there was about eighteen inches of flood water there.

Although New Zealand has been settled for over a century it is only since the passing of the Soil Conservation and Rivers Control Act in 1941 that there has been general widespread activity on river control schemes. Early hydrological records are meagre and much of the investigation work has had to be done as for "Unmapped Territory." First class aerial photographs are available and much use is made of the work of Gerald Lacey (the Author's reference 2, also "Regime Flow in Incoherent Alluvium," Central Board of Irrigation, India, Publication No. 20, 18th July 1930, and "A General Theory of Flow in Alluvium," Jour. Inst. Civil Engineers, London, November, 1946, pp. 16-47). Several of Lacey's relationships have been checked against observed values in New Zealand and found to be in reasonable agreement.

In using the Author's formula (1) it is sometimes difficult to establish the regime width of channel and, when aerial photographs are available, a more convenient approach is by means of the minimum radii of stable bends in alluvium. A. P. Grant ("Channel Improvements in Alluvial Streams," Proc. N. Z. Inst. of Engineers, Vol XXXIV (1948) pp 231-304) gives this as:-

$$\text{Radius of bend in feet} = 11\sqrt{Q}$$

When marks enable a reasonable estimate to be made of a bank-full flood gradient in incoherent alluvium the Lacey formula:-

$$V = 16\, R^{2/3} S^{1/2}$$

is a valuable reconnaissance aid.

For velocity observations bamboos make useful floats and are often readily obtainable in tropical countries. They can be weighted at one end to submerge them through much of the depth of the water. Their speed then approaches the mean velocity for the vertical filament in which they travel.

The Author's Slope-Competence-Depth relationship is a notable contribution and will receive further attention in New Zealand, where rivers are short

1. Soil Conservation and Rivers Control Council, Wellington, New Zealand.

and many carry shingle right to the sea. It is immediately apparent that no New Zealand river carrying shingle in any quantity is tranquil, as few transport stones at slopes of less than 5 to 6 feet to the mile. Unfortunately the writer has little data on largest rolling diameter, local observations being concentrated on the mean diameter. In the few checks it has been possible to make there is a reasonable agreement with the Torrential curves.

E. KUIPER.[1]—The very interesting discussion of short-cut river survey methods by Mr. Matthes was greatly appreciated. During hydrometric surveys on the Assiniboine River and the Saskatchewan River in Canada, the writer had opportunity to test similar methods and came to conclusions which very much confirmed the experience of Mr. Matthes. By analyzing numerous current-meter measurements, it was also found that the ratio between the average velocity and the maximum surface velocity was roughly 0.8.

When timing the velocity of driftwood over a given length of river channel became difficult because of the inaccessibility of the river banks in which the distance had to be laid out, the following method was used. The boat was kept floating on the river in the middle of the current. The velocity was determined by timing the progress of the boat on aerial photographs for several miles. At the same time, the maximum depth was determined by continuous sounding. Since the scale of the aerial photographs was known, the width of the river and the length of the timed section could be determined. By multiplying the velocity of the boat with a factor 0.8, the mean velocity was estimated. By multiplying the average sounded depth with a factor 0.66, the mean depth was estimated. By multiplying the mean velocity with the mean depth, and the mean width from the photographs, the estimated discharge was determined. It was recognized that the result could be up to 30 per cent in error, but failing more accurate measurements, such a rough estimate was often valuable.

A short-cut method to determine the approximate sediment concentration in a river was based on a method that is reported to be used in Russia. A disk, painted white, is attached to a stick or pole and submerged in the river. The maximum depth at which the disk is visible is measured on the pole with a tape. When a few suspended-sediment samples, taken during medium, extreme low and high measurements of visibility, are analyzed in the laboratory, a rating curve for visibility versus sediment concentration can be made up.

The writer cannot quite agree with the method that Mr. Matthes proposed for determining the river gradient by measuring the largest diameter of the river bed-material. First of all, it can be pointed out that the slope of a river not only depends on the size of the largest bed-material particles, but also on the gradation of the bed-material and on the amount of sediment that is transported. It would seem, therefore, that a unique relationship between the largest rolling diameter and the slope of the river cannot exist. On the Saskatchewan River, for instance, it was found at the head of the delta area, that the largest rolling diameter was about 10 m.m., the depth of flow 20 feet, and the slope one foot per mile. In the middle of the delta area, the largest rolling diameter was about 2 m.m., the depth of flow 40 feet, and the slope one-quarter of a foot per mile. These data do not fit at all in Figure 1.

Instead of using the bed-material diameter as an index, it may be possible to estimate the slope of the river by using velocity measurements and the Manning formula. If the maximum surface velocity and the maximum depth

---

1. Senior Hydr. Engr., P.F.R.A., Dep't of Agriculture, Canada.

are measured as discussed before, the average velocity and hydraulic radius can be obtained by multiplying the results with 0.8 and 0.66 respectively. If the observer is trained in estimating the hydraulic roughness of the channel on the basis of the appearance of the river and the composition of the bed-material, the slope of the river can be simply computed.

If a current meter is available, a more refined method can be followed. This method is based on the logarithmic velocity formula.

$$Vy = 33 \log 30 \frac{y.x}{Ks} . \sqrt{RS}$$

in which

Vy = the velocity at distance y from the bed
y = the distance from the bed
x = a parameter
Ks = the roughness of the bed
R = the hydraulic radius
S = the slope of the river.

When this equation is solved for two values of y that differ a factor 10 in magnitude and the two equations are subtracted, the following equation remains:

$$Vy10 - Vy1 = 33\sqrt{RS}$$

This equation can be solved for S simply by measuring the velocity near the surface of the river and at one-tenth of the depth, measured from the bottom. By subtracting these two values and after substituting for R, the measured depth times 0.66, the value for S can be quickly computed.

Both methods have been applied to several observations on the Saskatchewan River. Errors in the slope estimate of 100 per cent were possible especially if it was assumed that nothing else but the velocity and depth at one vertical were known. Since it seems that Figure 1 is also open to some degree of error, it may be of advantage to apply all three methods in a given case. An agreement of the three answers would be a strong indication that the slope estimate would be nearly correct.

C. J. POSEY,[1] M. ASCE.—The profession is indebted to Mr. Matthes for setting down in this paper a host of valuable items of information that only a person of his experience and rare scientific ability could have accumulated. At one point the author's logic eludes the writer, who has supposed that there is no reason to expect appreciable superelevation of the midstream water surface of even the swiftest stream unless the cross-sectional shape is changing, a case which seems to be ruled out by the stipulation that "the V/V_{cs} method is applicable only to straight reaches between well-defined parallel banks."

In measuring currents in models by photographic methods, it is sometimes impossible to tell which direction a float moved along the streak recorded on the photograph. The writer has described a method for circumventing this difficulty by means of a flash at or near the end of the time interval of the exposure.[2] It seems possible that some variant of this technique could be used with actual estuaries.

1. Head, Dept. of Civ. Eng., State Univ. of Iowa, Iowa City, Iowa, and Director, Rocky Mountain Hydr. Lab., Allenspark, Colo.
2. "Photographic Technique for Recording Direction of Surface Currents in Models," Civil Engineering, V. 9, p. 619, October 1939.